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December 19th, 1991

The Office of the Secretary
Federal Communications Commission
1919 M Street, NW
Washington, DC 20554

Dear Mr. Secretary:

Kindly find enclosed a copy of MIT Media Lab's comments to FCC Docket 87-268, submitted on behalf of all the researchers at the Media Lab, and in response to Notice of Proposed Rule Making on Advanced Television Systems and Their Impact upon the Existing Television Broadcast Service.

I have also sent under separate cover copies to the Chairman Sikes, Commissioners Barrett, Duggan, Marshall and Quello those listed below, enclosed in your one package. I would appreciate these being delivered to their respective offices.

Your cooperation is appreciated.

Yours sincerely,

Andrew Lippman
Associate Director

Encs.

cc: Richard Firestone, Common Carrier
Roy J. Stewart, Mass Media
Robert Pepper, Office of Plans and Policy

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Federal Communications Commission
Office of the Secretary

Before the
Federal Communications Commission
Washington, D. C. 20554

In the matter of
Advanced Television Systems
and Their Impact upon the
Existing Television Broadcast Service

MM Docket No. 87-268
Notice of Proposed Rule Making
November, 8, 1991

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Comments of
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December 19, 1991

The opinions expressed herein represent the collective thoughts of the researchers in the MIT Media Laboratory

Summary

The Commission has taken a bold and visionary approach to the matter of Advanced Television Broadcasting in America that should serve as a world model for in years to come. In this note, we comment specifically on ¶36, ¶42, ¶45 and ¶47 of the Notice of Proposed Rule Making dated 8 November, 1991, with an eye to further refinement of the inquiry. The essence of the presentation is that the foremost characteristic of Advanced Television has within the past 18 months shifted from definition to digitization. Digital television can eclipse high definition as the key to a new broadcast service.

A forward-looking approach to digital transmission can provide two specific advantages: (1) a scalable representation that is equally suitable for all channels including broadcasting, cable, direct broadcast satellite, telephony and package media, (2) a universal digital broadcast channel that can deliver television at a variety of line counts and frame rates or can be used for non-television services. The ability to multiplex 525 line signals in a digital broadcast medium can provide social benefits to people, new economic advantages to existing and new broadcasters, and at the same time, has the potential to unify diverse distribution channels. In addition, it can lead to international harmony.

Introduction

We are at a watershed in the history of television. Twenty years ago, higher definition motivated a revival of engineering interest in a stable field. However, improved clarity requires a signal format, a compelling display and must be good enough to be worth doing. It also requires a commercial commitment that starts at the program source and ends at the consumer's home. It now appears that the displays needed to excite the consumer are some time away, but the signal is almost ready. Therefore, the balance of interest has necessarily shifted from increased line count to improved apparent quality and new services. HDTV as popularly discussed is but one component of a more significant transition from analog to digital television. It may not even be the most important one. The element that allows new opportunities is the *digital representation*, not the line count.

In the past eighteen months, there has been a universal recognition that the advanced television signal in all regions of the world and in all delivery media will be digital. While other countries may argue that digital television is some time away, all agree that it is inevitable. In America, we seem committed to an early transition; as a result, we may lead the world.

The advantages of *digital* television include extended quality, increased program diversity and enhanced viewer options. A digital signal is not only efficient, it can carry information about its format, its content and its intent in a way that simpler analog representations can only approximate with digital overlays. Digital television is not simply efficient – although it is at least that – it is a change in style, a new generation of the medium and it will guarantee new kinds of content.

In any region of the world, there are five opportunities for the delivery of advanced television to the home: broadcasting, cable, DBS, telephony, and package media. In the immediate and long-term future, it is reasonable and desirable to expect each of these channels to prosper; none need exist exclusively.

A new television service involves a major infrastructure change as well as new consumer equipment. By virtue of the scale and importance of video in everyday life, it is insufficient to define an advanced television standard without consideration of the impact of that standard on *all* feasible distribution media. We are facing a change to general and global digital communications, not just a new terrestrial broadcast receiver. Such an opportunity is precious; rarely do we get the chance to transform the infrastructure of television.

The imperative is that a transition to digital television be done in a coherent manner among all delivery paths to allow the full range of systems and services to flower. Many of the advantages will be delayed or lost if an incoherent approach is taken, and some of the seemingly more complex or futuristic opportunities become readily available once the decision to represent video digitally has been made. In an all digital receiver, the increased cost of doubling the complexity of the signal decoder, for example, can be a negligible fraction of the price of the entire unit.

Digital broadcasting also implies the ability to allocate program space to interests heretofore excluded and to generalize the spectrum past allocation to specific content or formats. UHF need not be dedicated solely to television service. Bits are bits - their meaning can be divided among television, radio and pure data dynamically or in a market-driven fashion. The raw efficiency of digital broadcasting holds the potential to move television out of the VHF band entirely, leveling the playing field for all broadcasters and freeing valuable spectrum for other uses.[1]

This is independent of whether the modulation has a hard or a soft threshold. The fundamental point is that the broadcast channel is no longer locked to the baseband signal, it is a generalized data delivery medium regardless of the standard.

Digital Television

There are several technological pushes toward digital television including:

1. The demonstration of ISO/MPEG as a realizable standard;
2. The consumer introduction of CD-I;
3. The emergence of four fully digital Advanced Television Broadcasting proposals;
4. Engineering advances in videotelephony, multimedia computing and video.

In addition, there are demand pulls that result from the efficiency and flexibility afforded by digital distribution:

1. Multiplexing channels saves communication space and costs;
2. Widescreen receivers and higher picture quality can be an evolutionary rather than stepwise change in television if an appropriate picture format is chosen, thus easing the transition from existing standards;
3. Video on demand is a recognized economic opportunity;
4. New consumer devices are starting to create personalized control over recording and subsequent viewing.

Digital television is available and desired.

Broadcast Opportunities

A digital format equates the service opportunities available to broadcasters with all other media. The major difference remaining between the five paths to the home is the backchannel. In some cases (cable and telephony), it comes with the wire; in others, it is circuitous, involving a smart card and/or a telephone line.

1. Other uses *includes* but is not limited to simulcasting as suggested in ¶45.

Broadcast television, if used for digital multiplexing, provides essentially the same services at the same capacity as the other channels noted. The UHF band in a locality can carry as many as 224 channels at 525 lines each[2] if four programs are carried in a single 6MHz allocation.

Access to the airwaves is simplified with such a vast increase in program channels per locality and the inequity between UHF and VHF disappears. *If a goal of the FCC is to advance television and re-allocate the valuable VHF spectrum, the Commission can do this as much as ten years earlier by promoting digital broadcasting of anything but HDTV.* This argument bears on ¶36 and ¶42 and suggests that shifting ATV services back to pre-existing NTSC channels should *not* be done when the NTSC channel involved is in the VHF band. A goal of this inquiry should be the contiguous allocation of new digital services wholly within the UHF band to free space for other uses, and to provide equality of service options.

Digital cacophony

A major impediment to this digital evolution is the divergence of technologies.[3] An incomplete list includes MPEG-II, CD-I/MPEG-I, cable initiatives, DBS initiatives, this pending inquiry. While it is feasible to distribute multiple algorithms and encodings to a programmable decoder, a common language or *meta-standard* must exist by which the algorithm specifics can be interpreted. There are groups addressing multiple formats under the rubric of *headers,* but this activity is only beginning. Further, most consumer products suppliers desire the least expensive in-home apparatus, and programmability may not compete with dedicated devices until perhaps the turn of the century.

In addition to the obvious reasons for avoiding inconsistent standards (profusion of consumer boxes, etc.), it is important to consider other factors that affect digital video in the home and work environment.

Real-time: Video by its real-time nature, places particular access and bandwidth requirements that might restrict the algorithmic options. A digital VCR, for example, may rely on segmenting tracks to gain capacity and this may couple some access options to the digital data format. Similarly, multiple programs or alternate views of a single event might have to be interleaved or multiplexed. Multiple sound sources and choices are addressed by some proposers, but all assume a single video track.

Multi-format: Progressive sources (film) have been around for years, but multiple format monitors are only emerging. Europe is starting to move to 100 Hz displays, Scandinavian computer terminals must have refresh rates

2. In this note, 525 line television denotes only the line rate. Component formats such as CCIR-601 can provide markedly better perceived images without changing the display technology of the consumer receiver.

3. Comment on this is requested in ¶47: Harmonious, scalable and interoperable television.

above 72Hz, scan-conversion television receivers have been introduced in America and Japan, data display terminals are diverging from standard television rates. It is desirable for the format to be as independent as possible from the display characteristics. In fact, the mating of the scanning standard and the image format is a historical artifact of synchronous, analog television, no longer necessary or even desirable.

Re-coding: While there may be some delay-sensitive material such as videotelephony or live sports and news, better compression can always be done asymmetrically, to exploit deeper correlations in the data. While a programmable television could accept multiple standards, in-home equipment cannot be expected to efficiently recode diverse algorithms

Advanced Television

The MIT Media Laboratory has been demonstrating advanced television features for years, many of which are directly applicable to near-term digital television systems. None of these has a history on which to base their value – they have neither succeeded nor failed in the past. However, they are options that may have value in the future. They should be considered in any advanced television process because we do not know enough to preclude them as valuable social service opportunities and because their cost may be low enough to warrant speculation. To reiterate: **a new infrastructure change must consider even its least likely *but possible*** uses. A short list is presented below:

Designer Channels: The profusion of programming options literally demands an intelligent intermediary between the tuner and audience, if only to pre-select choices. It is reasonable to extend this to tuners and recorders that make a television appear to have only one channel, the one you are interested in watching.

Picture in Background: Instead of PIP or POP[4], the notion is a receiver always attuned to programs that are not on the screen, ready to interrupt on content criteria, or in the course of grazing, or for staging for later viewing.

Multi-Programming: A *program* can evolve to become a conceptual sequence rather than a single video track. Currently, this approach is taken with multi-channel sound; multi-programming extends it to pictures.

Pay per view per bit: The idea is to allow various delay and quality factors to be dynamically used in the distribution of programs: quick-and-dirty versus slow and clear, low-cost versus high-end programs. There is no reason to believe that anyone would pay more for a program in higher fidelity, but it has never been an option before; nor has distribution without an implicit time scale.

4. Picture in Picture, or Picture *Out* of Picture. The latter has been suggested for widescreen receivers.

Synthetic Programs: A step beyond designer channels, the idea is the creation of a program within the receiver, as in a news presentation culled from diverse sources.

The Everyday Videophile: Currently, there is a huge gap between videophiles and the average viewer. This results in a distorted market addressing one or the other. Digital television allows a more complete range of features and quality levels and may unearth a similar range of audience tastes.

Video downloading: This is an extension past narrowcasting to a television pre-loaded to appear as a random access medium. In advertising, this implies a different advertisement for each viewer.

Scalable Video

We have written extensively about scalable video.[5] [6] For the purpose of discussion, we divide scalability into four components:

1. Multiscale display: encoding to facilitate display at multiple sizes;
2. Multi-rate transmission: encoding so that the data stream can be subsampled;
3. Multi-rate display: also investigated as Open Architecture Television, this is a frame-rate independent format;
4. Variable complexity decoding: we view decoders of lower complexity as feasibly producing a minified or reduced quality image sequence.

Of these, items two through four are of the most importance, the first is a corollary of the second or fourth. Multiscale display is imperative because it allows us to construct television systems measured in lines per inch instead of lines per screen.

We have successfully argued scalability as a *requirement* of MPEG-II; the onus is on us to show that it can be included without significant cost in either full-scale quality or complexity. Certainly a scalable signal is *possible,* but the cost and ultimate quality are a matter for further engineering.

Scalability is invaluable in home television on the basis of dynamic bandwidth allocation, variable rate recording without decoding on diverse consumer devices, integration with other home equipment, and distribution through heterogeneous channels.

In terms of a new broadcast television service, a scalable signal allows an evolutionary approach to increased definition. The same scalable signal can be decoded at a variety of resolutions and decoder costs, allowing

5. Comment on scalability is requested in ¶47.
6. "Feature Sets for Interactive Images", CACM, Vol. 34, No. 4, April 1991/"Open Architecture Television", Bove, V.M., Lippman A.B., 25th SMPTE Television Conference Proceedings, February 1991/"Multiscale Coding of Images", MIT MS Thesis, July 1988/"Vector Quantization for Spatiotemporal Subband Coding", MIT MS Thesis, February 1990.

broadcasters and consumers alike to invest in as much definition as they wish, in a smoothly continuous manner.

Extensibility is to a great degree a corollary of scalability. While 2000-line video may never be broadcast terrestrially, extremely high resolution displays and imaging devices already exist in laboratories. There was a conference on Super-HDTV in Boston, Massachusetts in November. A generation of video beyond the current advanced TV proposals is in the making. The same coding techniques that provide scalable video also allow the representation to be extended without system re-design to suit new devices and channels.

We therefore urge that scalability be considered a requirement of a digital television image format.

Risks of Digital Broadcast

Many of the proposals for fully digital high definition television broadcasting include more complex electronics than a scalable video representation. Further, their coverage and efficacy is yet to be proven. If we test and authorize digital television solely for a high definition signal, and if that signal fails to reach the intended audience, all will be lost. On the other hand, a generalized digital channel can trade resolution for reach, diversity for reliability.

Conclusions

The nature of the change to digital video entails replacement of the television infrastructure. This demands a broad approach. The transition to digital television will occur once, if at all, and there is no guarantee that the various industries involved will take more than the simplest, most immediately beneficial approach. An infrastructure change as significant as this requires some coordination. The FCC is in the position to take the lead.

Advanced television discussion already includes dual-use technologies, digital broadcasting, and the general area of consumer devices other than TV sets. A broader view of the issue can show new opportunities for all interested parties and insure that high bandwidth digital communications thrive in an extensible, realizable and affordable way.

With respect to the ongoing FCC process, we see that broadcasting is one part of a much larger picture. We urge that the FCC broaden the inquiry to examine the use of the digital channel for data unrelated to HDTV or even television at all, and that image quality be tested scalably at both 525 lines and higher rates. Picture coding selection should be based on equal performance in all five channels discussed above: broadcasting, cable, direct broadcast satellite, telephony, and package media.

With respect to the use of the UHF spectrum for services other than television, we suggest that once the data are digital, the content, format and application can be a matter of market dynamics instead of legislative mandate. By allowing a diversity of services, the issue of allocation is revised and simplified. It can be reduced to dividing spectral regions between centrally located broadcast services and point-to-point applications, but the signal and purpose need not necessarily be adjudicated at all.

We also present scalability as an important component of the definition of a new picture representation, becoming accepted within many communities. An extensible, scalable system *is* possible. Finally, a scalable system holds the potential to unify digital television communications throughout the world.